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SOME RELATIONS BETWEEN NERVOUS TISSUE AND GLANDULAR TISSUE IN THE TUNICATA.

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IT is well known that in the ascidians the definitive brain and the neural gland are both derived from the same region — the trunk region of the central nerve tube of the tadpole. The ganglion is derived from one wall of this tube, and the gland is derived from the opposite wall. Six years ago I pointed out that the ganglion of *Salpa* is homologous with both the ganglion and the neural gland of ascidians; the dorsal part of the *Salpa* ganglion corresponding to the ascidian brain, and its ventral part corresponding to the ascidian neural gland.[1] That is, a certain portion of the embryonic nervous system in ascidians becomes transformed into the neural gland, while in *Salpa* the corresponding region does not suffer this change, but remains as part of the definitive brain, its cells functioning as gland cells in the adult. I have recently found in the ascidians an interesting series of diverse conditions as to the origin of the gangliated nerve which runs down in the median line of the partition between pharynx and cloaca.

In this region, the dorsal raphe, one finds a large blood sinus, a muscle (either single or double), a gangliated nerve cord (the rapheal nerve), and frequently a prolongation from the neural

[1] "The Eyes and Sub-Neural Gland of Salpa," *Memoirs from the Biological Laboratory of the Johns Hopkins University.* Vol. ii, Part iv. 1893.

gland, which I have called the rapheal duct. In different species the rapheal nerve may arise from the cellular cortex of the brain, from the neural gland, or from a mass of cells formed by the fusion of the brain and the gland. The five accompanying diagrams show some of the conditions found.

In *Cynthia papillosa*, Fig. 1, the rapheal nerve arises from the cellular cortex of the brain. Alongside it in the raphe is found the unusually large rapheal duct, which has extended down from near the posterior end of the epineural gland. The rapheal duct and rapheal nerve are wholly distinct.

In *Distaplia magnilarva*, Fig. 2, there is no rapheal duct. The brain and neural gland are united posteriorly. The rapheal nerve arises from the cortex of the brain, a little behind the point of fusion of the brain with the gland.

In *Amaroecium constellatum*, Fig. 3, we find a rudimentary rapheal duct starting back from the gland, but it looses its lumen before going far, and then its cells become united with the cells of the brain to form a common mass of cells whose origin, whether from the brain or the gland, we are unable to determine. From this common mass of cells the *ganglion cells* of the rapheal nerve are derived, its *fibers* coming from the right posterior siphonal nerve.

In *Ascidia atra*, Fig. 4, we have a similar origin for the fibers of the rapheal nerve, but find an interesting difference in the derivation of its ganglion cells. A cord of cells pushes out from the dorsal surface of the brain, near its posterior end, and, after running back a short distance, unites with a backward prolongation of the gland, which runs up to meet it. The prolongation of the gland is evidently the rapheal duct. The two cords fuse immediately, the duct loosing its lumen. The single cord of cells thus formed runs back some distance and then bends down to accompany the fibers of the rapheal nerve. Its cells soon become loosely arranged among these nerve fibers and are clearly the ganglion cells of the rapheal nerve.

In *Phallusia mammillata*, Fig. 5, these organs are exactly similar, except that the prolongation from the dorsal surface of the ganglion does not unite with the rapheal duct, but bends forward, soon ending blindly. In this species, then, the ganglion

cells of the rapheal nerve are derived solely from the rapheal duct, which is a prolongation from the neural gland.

The ganglion cells of the rapheal nerve in *Phallusia* have therefore had a roundabout history. Certain cells of the larval nerve tube were pushed out to form the neural gland. A portion of these gland cells extended backward until they came in contact with the fibers of the rapheal nerve.[1] Here they lose their regular arrangement and become the ganglion cells of the nerve. There is no evidence that these particular cells, even though a part of the gland, were ever functional as glandular cells. The corresponding cells, however, in many other species are functional gland cells. (Compare *Cynthia papillosa* above.)

The facts referred to in this paper show a peculiarly intimate relation between glandular tissue and nervous tissue in the *Tunicata*, hardly to be paralleled elsewhere in the animal kingdom.

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[1] This is based upon the assumption that the rapheal duct arises as a down-growth from the definitive gland rather than by the metamorphosis *in situ* of the trunk portion of the nerve tube of the tadpole. The rapheal nerve in *Salpa* and probably in ascidians arises as a down-growth from the brain. It is probable that the rapheal duct arises in a similar way as a down-growth from the definitive gland.

EXPLANATION OF FIGURES.

Reference Letters.

a.s.n. = anterior siphonal nerve.
d. = duct from neural gland to ciliated funnel.
f.r.n. = fibers of rapheal nerve.
g.c. = cord of ganglion cells.
gg. = ganglion (brain).
gl. = neural gland.
g.r.n. = ganglion cells of rapheal nerve.
p.s.n. = posterior siphonal nerve.
r.d. = rapheal duct.
r.n. = rapheal nerve.

The figures are diagrammatic parasagittal sections of the ganglion and neural gland, a little to the right of the median plane. In Figs. 4 and 5 the rapheal duct, which in reality lies on the right surface of the ganglion, is shown, although in reality it lies much to the right of the plane of the rest of the section.

FIG. 1. Cynthia papillosa.
FIG. 2. Distaplia magnilarva.
FIG. 3. Amaroecium constellatum.
FIG. 4. Ascidia atra.
FIG. 5. Phallusia mammillata.

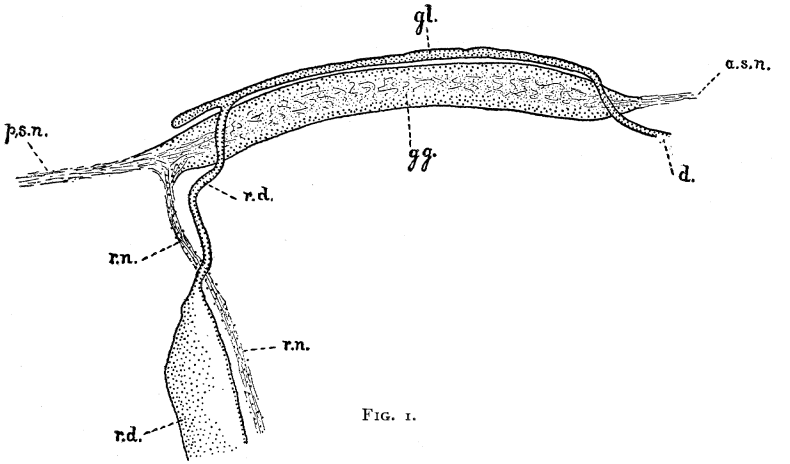

FIG. 1.

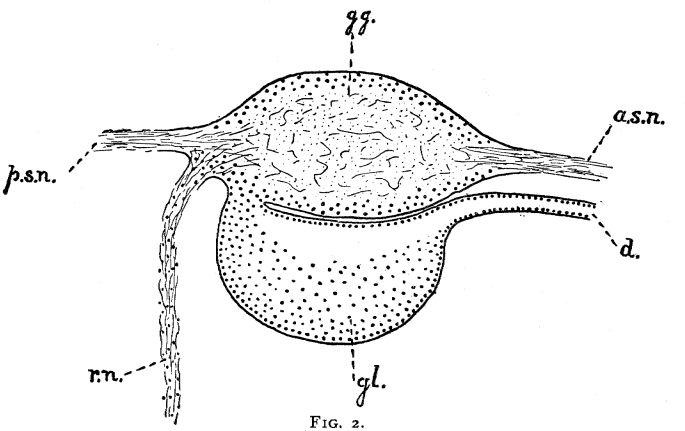

FIG. 2.

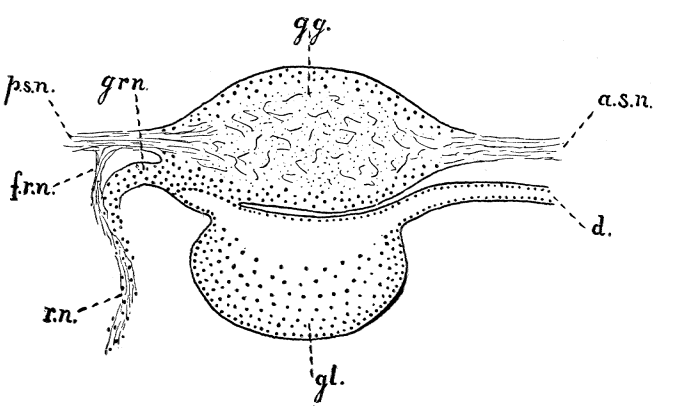

FIG. 3.

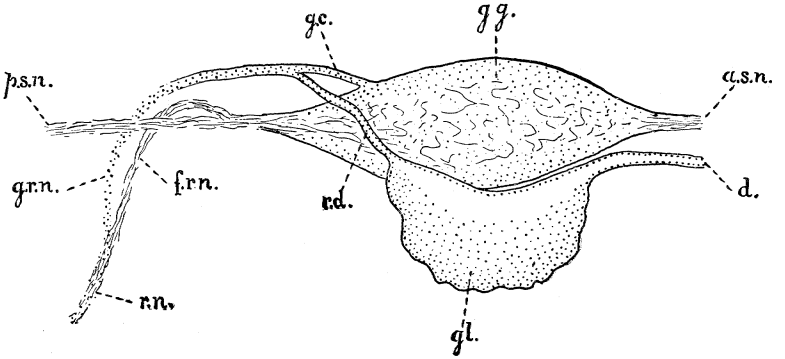

FIG. 4.

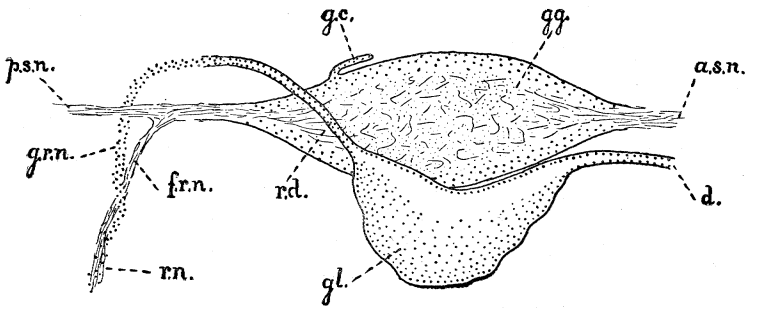

FIG. 5.